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Health Effects of Swimming in Lake Pontchartrain at New Orleans

Tulane Univ.
New Orleans, LA

Prepared for

Health Effects Research Lab.
Cincinnati, OH

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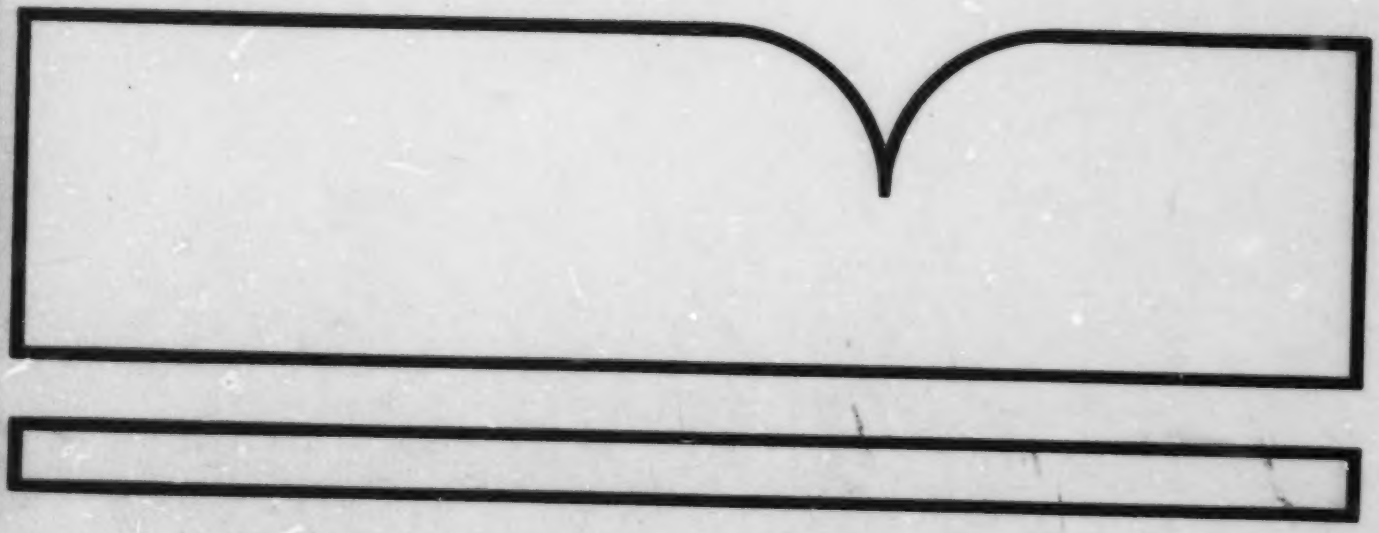

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16. ABSTRACT

This two-year study measured health effects of swimming in marine recreational waters in a sub-tropical climate by testing the association between reported post-swim symptom rates and density of bacterial indicator organisms. The study replicated previous investigations conducted at beaches in temperate climates. Variation in water quality at the same site provided bacterial exposure levels for swimmers. Data were obtained from approximately 5400 swimmers and 2300 nonswimmer controls over the two years.

The rates for gastrointestinal (GI) symptoms and the highly credible portion thereof were higher for swimmers than nonswimmers during both years of the study. This was also true of upper respiratory symptoms in 1978. Both in 1977 and 1978, the swimming associated rates for total and highly credible GI symptoms were higher for children than for adults. In both years a relationship between enterococci densities and gastrointestinal symptom rates in swimmers over age 9 establishes the importance of this indicator as a criterion of swimming water quality. Non-consistent findings for children with respect to E. coli do not rule out importance of this indicator but suggest perhaps a criterion level that could not be adequately tested in the second year.

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HEALTH EFFECTS OF SWIMMING IN LAKE PONTCHARTRAIN AT NEW ORLEANS

by

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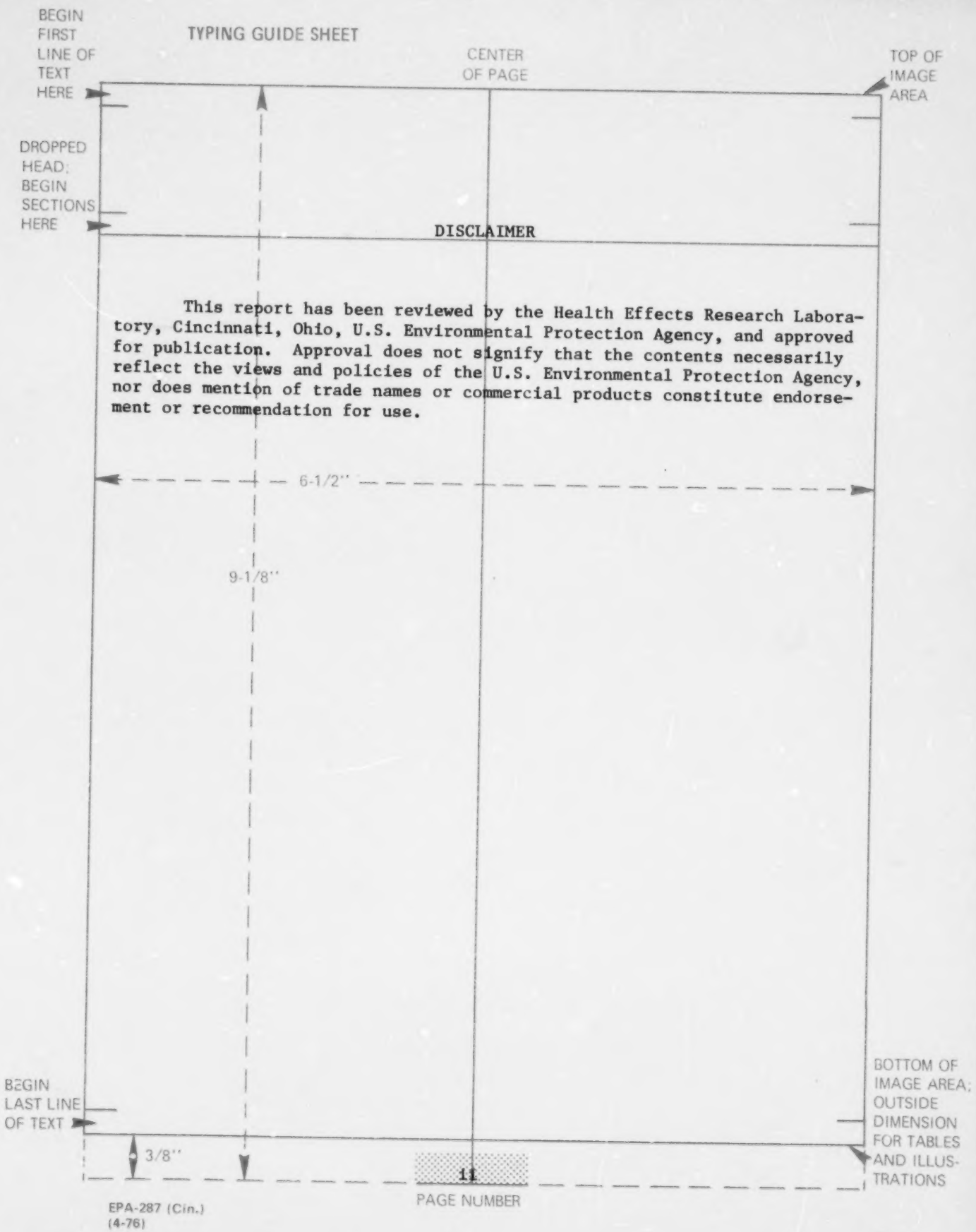
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FOREWORD

The U. S. Environmental Protection Agency was created in response to increasing public concern about the dangers of pollution to the health and welfare of the American people and their environment. The complexities of environmental problems originate in the deep interdependent relationships between the various physical and biological segments of man's natural and social world. Solutions to these environmental problems require an integrated program of research and development using input from a number of disciplines.

The Health Effects Research Laboratory was established to provide sound health effects data in support of the regulatory activities of the EPA. Evaluating man's exposure to environmental health hazards is a key segment in developing such a data bank. Studies of exposure require identification, characterization, and quantification of physical, chemical, and biological agents found in the environment. In addition, exposure assessment involves the determination of conditions that cause agents to be released into the environment, the study of the routes and pathways to man, and research into the body's ability to prevent the entrance of environmental hazards.

This report explores the relationship of the quality of water used for recreation and the resulting illness experienced by population studies. From this and other such studies a water quality criteria can be developed that will aid the Agency in developing water quality standards to allow for the beneficial uses of the Nation's waters.

R. J. Garner
Director
Health Effects Research Laboratory

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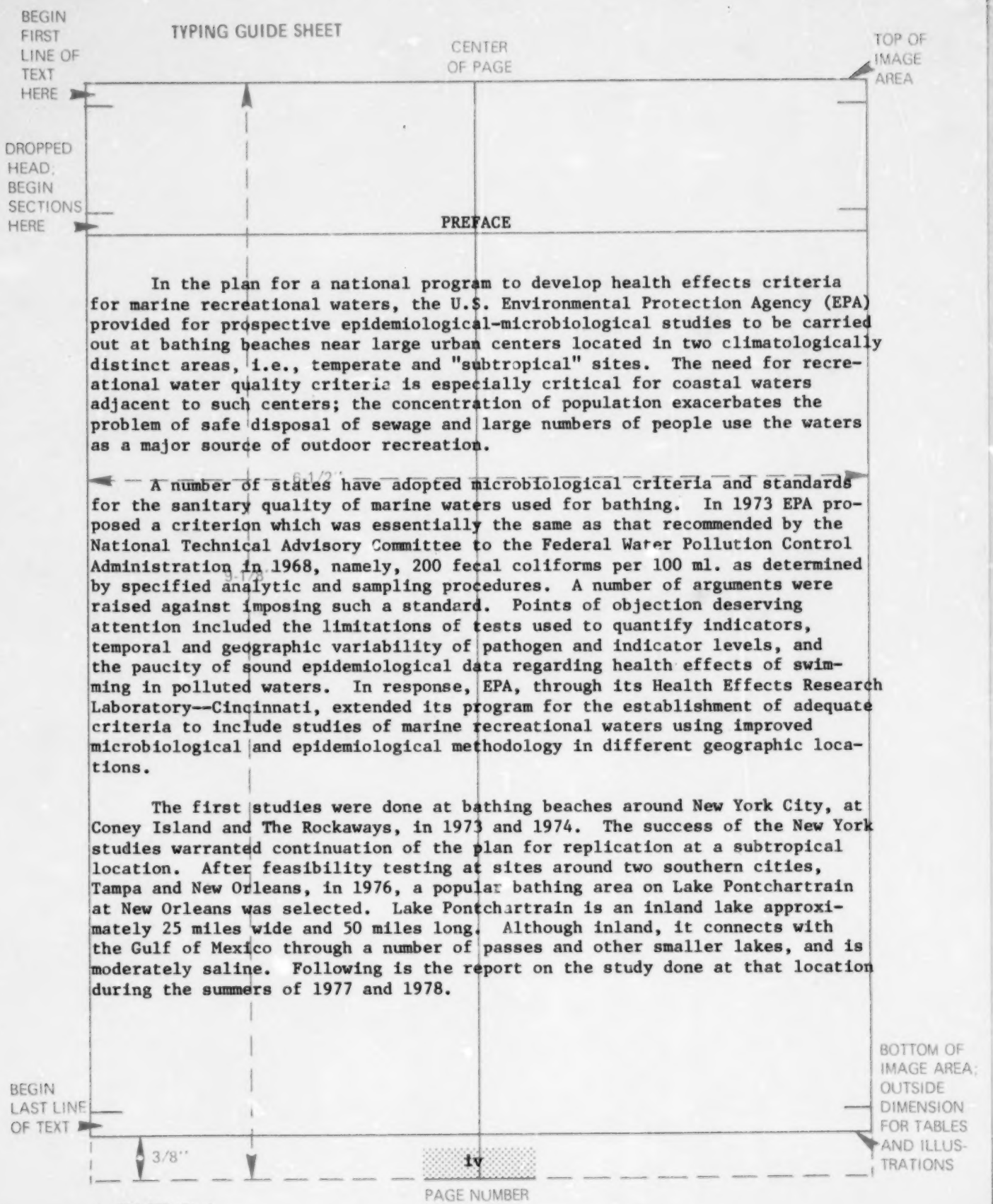
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PREFACE
In the plan for a national program to develop health effects criteria for marine recreational waters, the U.S. Environmental Protection Agency (EPA) provided for prospective epidemiological-microbiological studies to be carried out at bathing beaches near large urban centers located in two climatologically distinct areas, i.e., temperate and "subtropical" sites. The need for recreational water quality criteria is especially critical for coastal waters adjacent to such centers; the concentration of population exacerbates the problem of safe disposal of sewage and large numbers of people use the waters as a major source of outdoor recreation.
A number of states have adopted microbiological criteria and standards for the sanitary quality of marine waters used for bathing. In 1973 EPA proposed a criterion which was essentially the same as that recommended by the National Technical Advisory Committee to the Federal Water Pollution Control Administration in 1968, namely, 200 fecal coliforms per 100 ml. as determined by specified analytic and sampling procedures. A number of arguments were raised against imposing such a standard. Points of objection deserving attention included the limitations of tests used to quantify indicators, temporal and geographic variability of pathogen and indicator levels, and the paucity of sound epidemiological data regarding health effects of swimming in polluted waters. In response, EPA, through its Health Effects Research Laboratory--Cincinnati, extended its program for the establishment of adequate criteria to include studies of marine recreational waters using improved microbiological and epidemiological methodology in different geographic locations.
The first studies were done at bathing beaches around New York City, at Coney Island and The Rockaways, in 1973 and 1974. The success of the New York studies warranted continuation of the plan for replication at a subtropical location. After feasibility testing at sites around two southern cities, Tampa and New Orleans, in 1976, a popular bathing area on Lake Pontchartrain at New Orleans was selected. Lake Pontchartrain is an inland lake approximately 25 miles wide and 50 miles long. Although inland, it connects with the Gulf of Mexico through a number of passes and other smaller lakes, and is moderately saline. Following is the report on the study done at that location during the summers of 1977 and 1978.
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ABSTRACT

This two-year study measured health effects of swimming in marine recreational waters in a subtropical climate by testing the association between reported post-swim symptom rates and density of bacterial indicator organisms. The study replicated previous investigations conducted at beaches in temperate climates. Variation in water quality at the same site provided bacterial exposure levels for swimmers. Data were obtained from approximately 5400 swimmers and 2300 nonswimmer controls over the two years.

Indicators studied the first year were E. coli, Klebsiella, Pseudomonas aeruginosa, fecal coliforms, and enterococci. The first four organisms followed relatively the same concentration pattern while there was an inverse relationship between E. coli and enterococci after rainfall. For children under age 10 a significant positive association was found between gastrointestinal symptom rates and exposure to E. coli levels above 200/100 ml. No association was noted for enterococci. For older persons, age 10 and over, evidence of a relationship between symptoms and enterococcus density was strongly suggested.

The second year study focussed on the relationship of E. coli and enterococcus levels with swimmer illness. Bacteria counts were considerably lower, especially E. coli levels. First year results were partially substantiated in that illness rates were again higher for swimmers than nonswimmers and highest for young swimmers. No association, however, was found between either microbial indicator and symptom rates for children. For the older group there appeared to be an interaction effect of E. coli and enterococcus levels with symptom rates. Study of a small sample of swimmers at a less polluted site on the same lake (i.e., very low E. coli and equivalent enterococcus densities) corroborated the second year findings by age.

In both years a relationship between enterococcus density and gastrointestinal symptom rates in swimmers over age nine establishes the importance of this indicator as a criterion of swimming water quality. Nonconsistent findings for children with respect to E. coli do not rule out the importance of this indicator but suggest perhaps a criterion level that could not be adequately tested in the second year.

This report was submitted in fulfillment of Grant No. RA 805341-01 by Tulane Univerisity School of Public Health and Tropical Medicine under the sponsorship of the U.S. EPA. This report covers a period from July 9, 1977 to July 16, 1978, and work was completed as of August 7, 1979.

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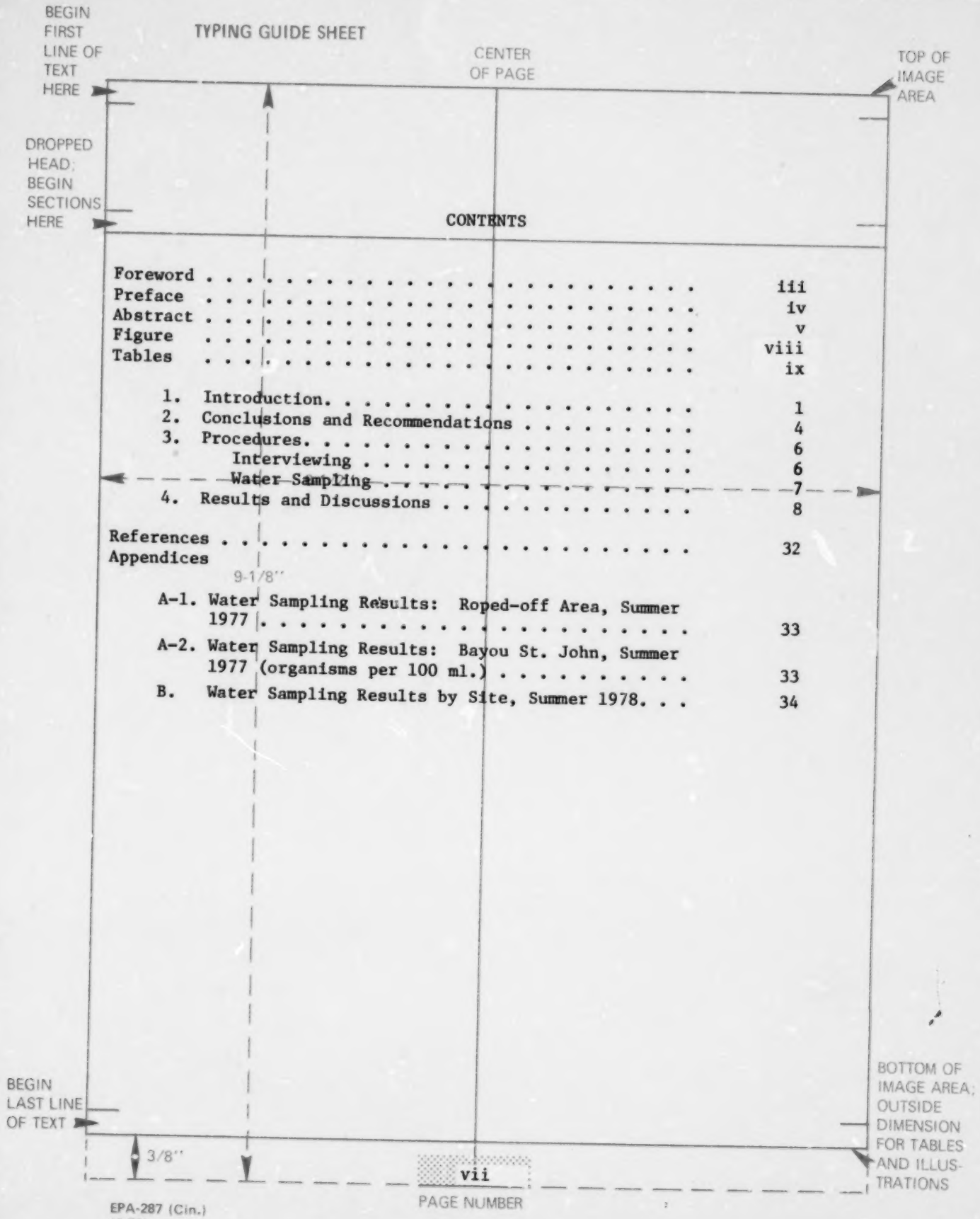
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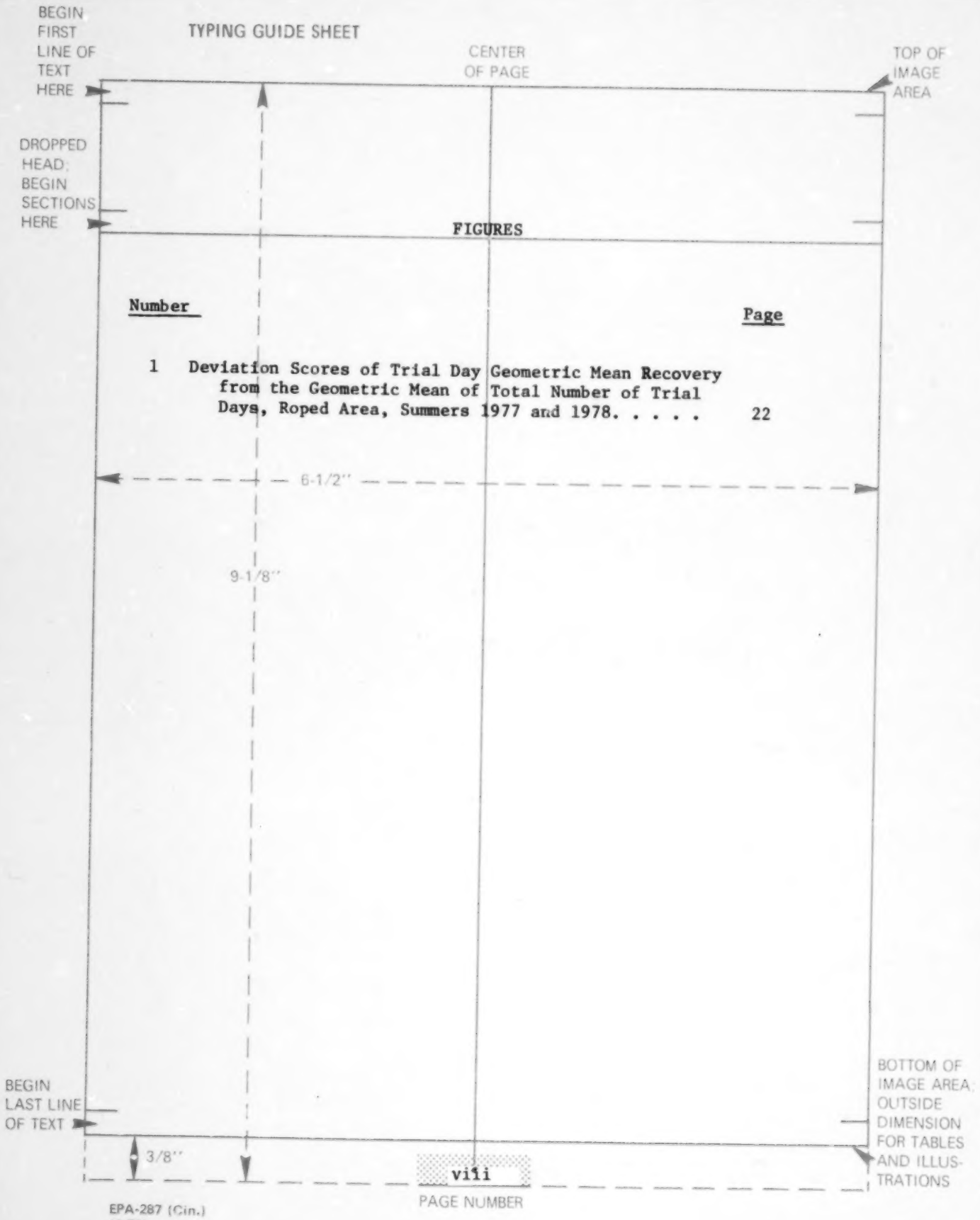
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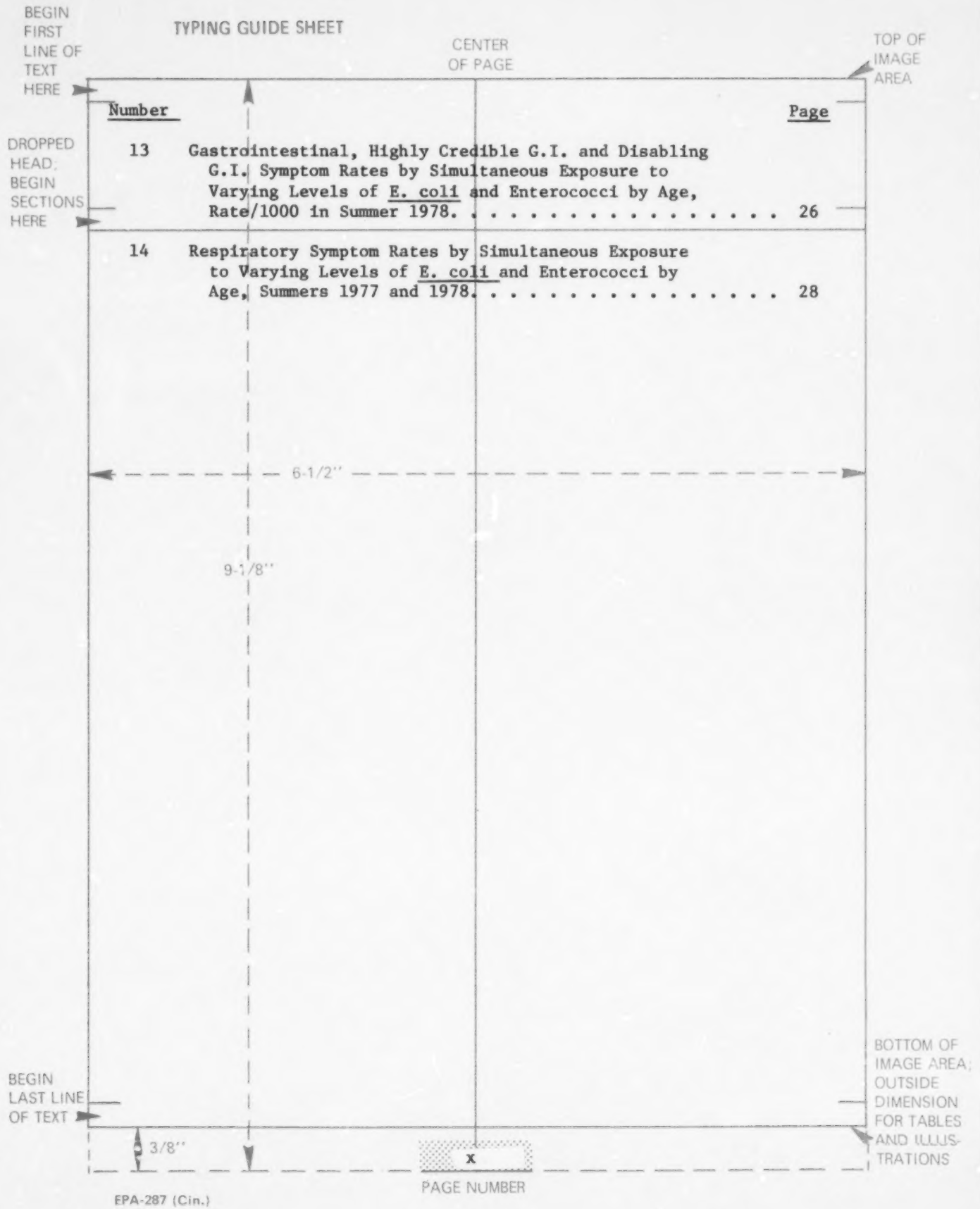
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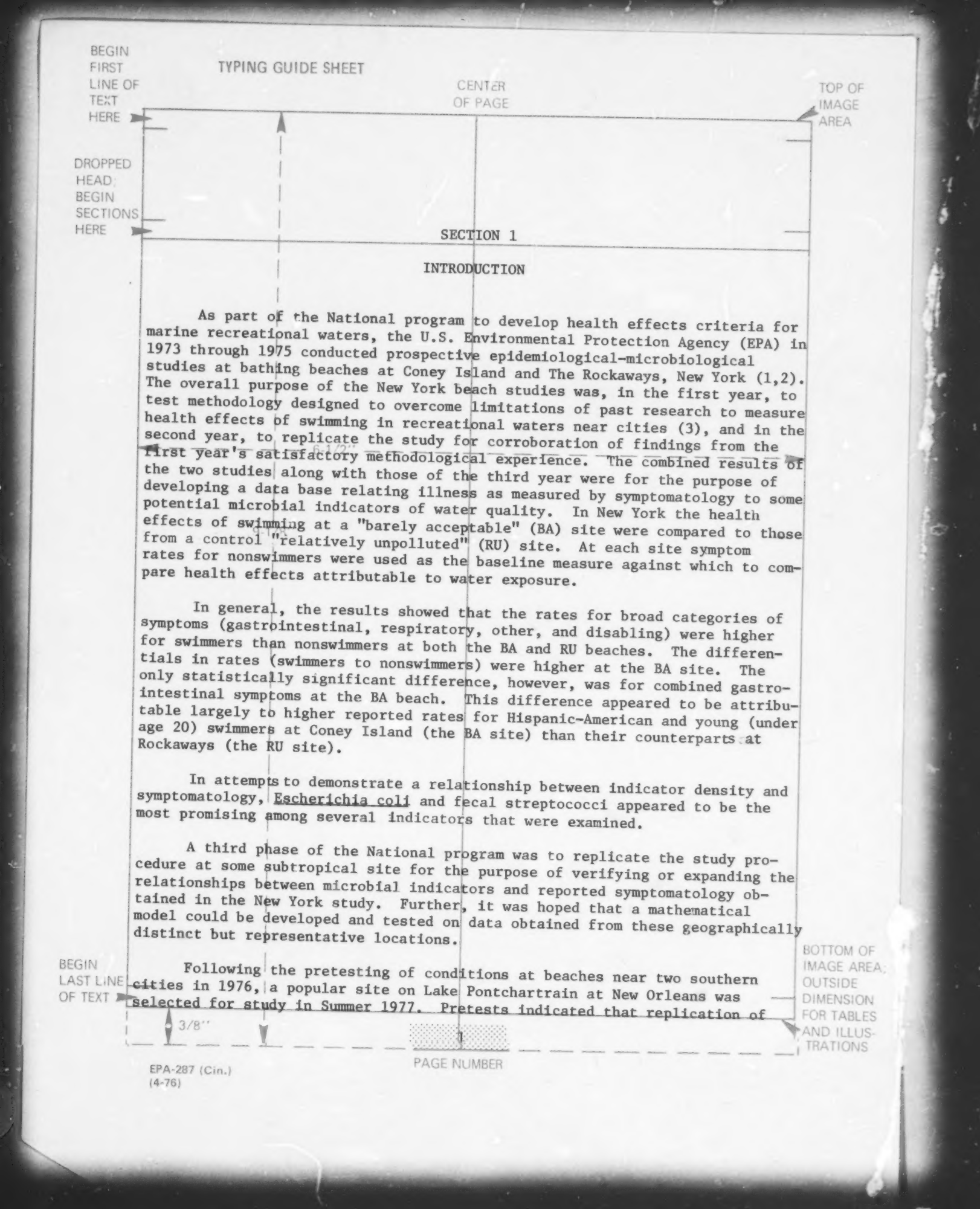
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SECTION 1
INTRODUCTION
As part of the National program to develop health effects criteria for marine recreational waters, the U.S. Environmental Protection Agency (EPA) in 1973 through 1975 conducted prospective epidemiological-microbiological studies at bathing beaches at Coney Island and The Rockaways, New York (1,2). The overall purpose of the New York beach studies was, in the first year, to test methodology designed to overcome limitations of past research to measure health effects of swimming in recreational waters near cities (3), and in the second year, to replicate the study for corroboration of findings from the first year's satisfactory methodological experience. The combined results of the two studies along with those of the third year were for the purpose of developing a data base relating illness as measured by symptomatology to some potential microbial indicators of water quality. In New York the health effects of swimming at a "barely acceptable" (BA) site were compared to those from a control "relatively unpolluted" (RU) site. At each site symptom rates for nonswimmers were used as the baseline measure against which to compare health effects attributable to water exposure.
In general, the results showed that the rates for broad categories of symptoms (gastrointestinal, respiratory, other, and disabling) were higher for swimmers than nonswimmers at both the BA and RU beaches. The differentials in rates (swimmers to nonswimmers) were higher at the BA site. The only statistically significant difference, however, was for combined gastrointestinal symptoms at the BA beach. This difference appeared to be attributable largely to higher reported rates for Hispanic-American and young (under age 20) swimmers at Coney Island (the BA site) than their counterparts at Rockaways (the RU site).
In attempts to demonstrate a relationship between indicator density and symptomatology, Escherichia coli and fecal streptococci appeared to be the most promising among several indicators that were examined.
A third phase of the National program was to replicate the study procedure at some subtropical site for the purpose of verifying or expanding the relationships between microbial indicators and reported symptomatology obtained in the New York study. Further, it was hoped that a mathematical model could be developed and tested on data obtained from these geographically distinct but representative locations.
Following the pretesting of conditions at beaches near two southern cities in 1976, a popular site on Lake Pontchartrain at New Orleans was selected for study in Summer 1977. Pretests indicated that replication of
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the epidemiological procedures of the New York study was feasible in terms of size of the beach-going population, its sociodemographic mix, and response rate. New Orleans did not provide, however, two distinctive bathing sites with respect to pollution level. The lake at this site was noted for almost day-to-day variation in fecal streptococci and fecal coliform densities, having been tested for a number of years by the City Health Department. The variation appears to be associated primarily with rainfall, an association that is so invariable that the Health Department abandoned an earlier practice of posting the beach "closed" on days when counts were high in favor of a permanently posted warning that "the water . . . is subject to intermittent pollution, especially after heavy rainfall."

The association between fecal coliform count and rainfall is attributed to the city's low-lying position, the high water table, and soil-settling characteristics. In Orleans Parish (county) the sewerage system is underground and ordinarily pumped into the Mississippi River south and east of the city. Because of differential settling, the pipes become cracked and broken. During heavy rains, as the ground becomes saturated, there is infiltration from sewage to drainage lines. To prevent flooding the excess water must be pumped out through canals. One such canal is the Orleans Outfall Canal through which water is pumped out into Lake Pontchartrain at a point approximately 1200 yards from Levee Beach, the site chosen for study. From contiguous Jefferson Parish, however, sewage is discharged into the Lake at several points, the nearest being about 2.5 miles from the beach. The flow from that point is in the general direction of the beach area.

Given the noted variation in microbial levels, plus climatological data for the past few years showing periods of dry and wet weather during each summer, it appeared reasonable to assume that in any given year the one site would provide both "experimental" and "control" conditions for measuring health effects associated with swimming in subtropical recreational waters under different levels of pollution.

For the New Orleans study, the number of indicators was limited to five: E. coli, Klebsiella, Pseudomonas aeruginosa, fecal coliforms, and enterococci.

Testing conditions the first year proved satisfactory. Promising techniques for measuring individual exposure to water conditions defined by indicator density were developed, and results with respect to swimmer-non-swimmer differential symptom rates and relationships between symptoms and indicator levels tended to corroborate the findings of the New York study.

The study was repeated the following year, summer 1978, using the same procedural design, at the same site, but limiting the indicators to E. coli, Klebsiella, and enterococci. A major unanticipated change in water conditions was observed the second year, however. There was considerably less variation in and lower levels of indicator densities, and the relationship of the indicators differed from one year to the next, particularly E. coli and enterococci. This effect was apparently attributable to "natural" causes since no changes had occurred in sewage disposal or storm water runoff provisions for the city. The month prior to study, however, ten inches of rain had fallen on the city in the matter of a few hours which may have had a cleansing

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effect.
In the second year, also, the attempt was made to study a second site on the opposite side of the lake known to be less polluted.
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SECTION 2

CONCLUSIONS AND RECOMMENDATIONS

The results of this study measuring health effects of swimming in relation to specific indicator organisms present in the subtropical water of Lake Pontchartrain are as follows:

Rates for swimmers were generally higher than rates for nonswimmers for a variety of symptoms, including gastrointestinal, respiratory, eye-ear-nose, and other. For gastrointestinal symptoms the swimmer rates were consistently significantly higher. Diarrhea was the most frequently reported specific symptom among swimmers.

Children under age 10 who swam showed the highest gastrointestinal symptom rate (12 percent) and the greatest swimmer-nonswimmer difference (six percent). The symptom rate for swimmers age 10 and over was approximately eight percent and the swimmer-nonswimmer difference three percent.

In the second year, statistically significant rate differences were found between swimmers and nonswimmers in the older but not the younger age group for symptoms other than gastrointestinal. The rates for older and younger swimmers were essentially the same, but the rates for young nonswimmers were higher than the rates for older nonswimmers, resulting in a considerably smaller swimmer-nonswimmer difference for the young. The disparity in these findings by age suggests that the etiological agents for these symptoms are not necessarily water-related. The consistent significant findings both years for gastrointestinal symptoms regardless of age, however, is evidence for the argument of the presence of microbial agents in Lake Pontchartrain that are associated with these type complaints.

Investigation of the relationship between microbial indicators and symptomatology strongly suggests different importance of two indicators, E. coli and enterococci, by age. A significant association between E. coli density above 200/ml. and gastrointestinal symptom rates for children was found the first year. This, however, was not substantiated the second year, perhaps because E. coli densities only slightly above this level were found on only three of the 12 trial days. The absence of an enterococcus effect either year for children is viewed as important for further substantiation. A positive relationship between enterococcus density and gastrointestinal symptoms for the older age group appeared in the findings both years, either independently or in interaction with E. coli.

Lake Pontchartrain is probably more unique than typical of a marine recreational bathing site in the subtropical region, hence generalizations of

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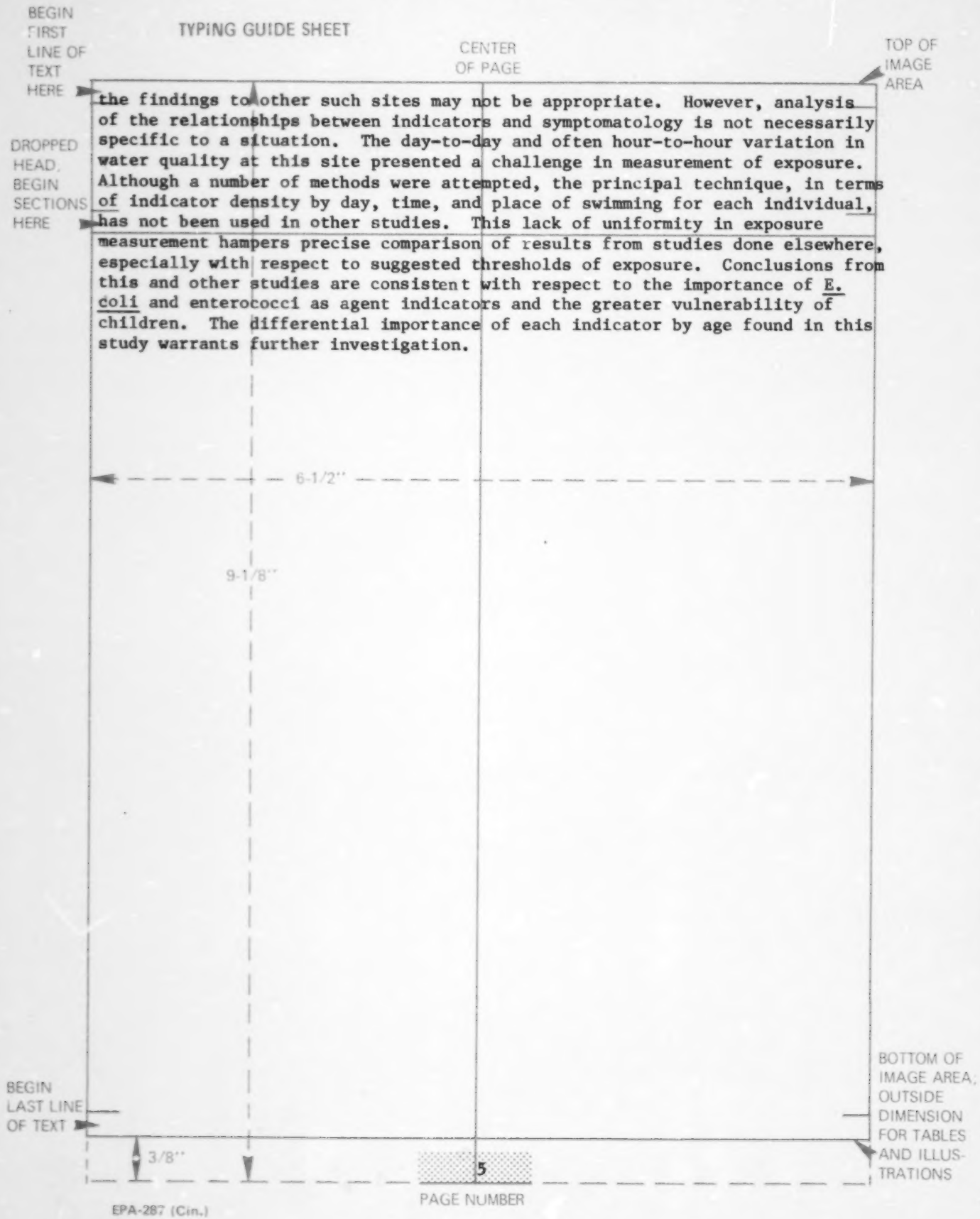
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the findings to other such sites may not be appropriate. However, analysis of the relationships between indicators and symptomatology is not necessarily specific to a situation. The day-to-day and often hour-to-hour variation in water quality at this site presented a challenge in measurement of exposure. Although a number of methods were attempted, the principal technique, in terms of indicator density by day, time, and place of swimming for each individual, has not been used in other studies. This lack of uniformity in exposure measurement hampers precise comparison of results from studies done elsewhere, especially with respect to suggested thresholds of exposure. Conclusions from this and other studies are consistent with respect to the importance of E. coli and enterococci as agent indicators and the greater vulnerability of children. The differential importance of each indicator by age found in this study warrants further investigation.
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SECTION 3

PROCEDURES

INTERVIEWING

Epidemiological data were obtained through a two-stage interviewing process. On weekends, Saturdays and Sundays, beach-goers were interviewed face-to-face, or through an informant for a group (as for a family), by trained interviewers using a standarized precoded schedule. A letter of appreciation for study participation and a reminder that study personnel would be calling for a report on any symptoms that occurred following the day at the beach was sent immediately thereafter. Telephone interviews were conducted eight to 10 days later for this report.

Beach Interviews

Interviewers approached primarily families or groups of beach-goers as they were ready to depart and screened them for study eligibility (i.e., persons who had not been swimming during the previous week). Restricting respondents to weekend-only swimmers was a control for exposure site.

The following information was obtained on each eligible person: sex, age, race or ethnicity, whether or not the person swam and got their head or face wet (swimmers were defined as those who were in the water at least 10 minutes and who got their face or head wet), length of time and time of day in the water, swimming location, illness symptoms the previous week, and for those who did not swim, the reason for not going into the water. An address and telephone number was requested for further contact.

The first year, 1977, beach interviewing began July 9, and continued each Saturday and Sunday for eight consecutive weekends. Rain precluded interviewing on one of these 16 days, and equipment failure eliminated water analysis on another. Complete information was obtained for 14 trial days. In 1978, the starting date was earlier, June 10, and interviewing continued for six successive weekends, through July 16, for 12 trial days.

Telephone Interviews

Eight to 10 days after the beach interview, telephone interviewers, most of whom were public health and medical students trained and supervised by project personnel, called respondents to determine their continued study eligibility (i.e., no intervening swimming event) and to obtain the date of onset of any symptoms occurring between the beach interview and the telephone call. Only symptoms occurring within seven days of being at the beach were given consideration.

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In 1978 respondents were also asked for duration of reported symptoms. (See Table 2 for symptoms queried) At the close of the telephone call, information was requested to calculate a "crowding index" (person/rooms ratio) to be used as an indicator of socioeconomic status.

WATER SAMPLING

Water samples were collected periodically during the time of maximum swimming activity. Two samples were collected from each of two contiguous locations of swimming concentration, the roped area and the Bayou St. John outlet. In 1977, the samples were taken three times each day--at 12:00, 2:00, and 4:00 P.M., and in 1978 only two times, at 11:00 A.M. and 2:00 P.M. All samples were collected at waist depth approximately four inches below the surface of the water. Upon collection, the samples were iced and delivered to the laboratory within eight hours. Five indicators were examined the first year: Escherichia coli and Klebsiella densities were obtained using the mTec procedure (4). Enterococci and Pseudomonas aeruginosa were quantified using membrane filter procedures designated mE and mPA, respectively (5,6). Fecal coliforms were obtained using the membrane filter technique outlined in Standard Methods for the Examination of Water and Wastewater (7). In 1978 only E. coli, Klebsiella, and enterococci were quantified. The procedures were the same as those used the previous year.

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SECTION 4

RESULTS AND DISCUSSION

RESULTS

Beach Contacts

The beach interviewing experience was the same each year with one exception. Since there is a greater concentration of beach-goers earlier in the season as opposed to later, more contacts were made in a shorter period of time in 1978 than in 1977. This seeming advantage the second year was partially offset, however, because more weekend swimmers earlier in the season also swam midweek, making them ineligible for the study. In 1978, approximately 2000 more beach contacts were made in six weekends than were made in eight weekends in 1977 (9,806 persons compared to 7,718). In the second year, however, one quarter of the contacts were ineligible because of prior midweek swimming; in 1977 only one-fifth were ineligible for this reason. More persons were also disqualified at telephone follow-up the second year because of midweek swimming. Overall response loss due to midweek swimming was 27 percent the first year and 34 percent the second year.

Among eligible persons at the beach, the ratio of swimmers to nonswimmers was essentially the same the two years (71 and 73 percent swimmers, respectively); the percent providing telephone numbers was 90 percent the first year and 86 percent the second year; and telephone follow-up was successful on 77 percent of these each year. This corresponds to the 78 and 83 percent success reported by Cabelli for the New York study in 1974 (1).

Comparison of demographic characteristics of the total number of study eligibles on whom information was collected at the beach and the final sample on whom telephone follow-up was obtained showed remarkedly the same percentage distributions with respect to sex, age, and ethnic classification for both swimmers and nonswimmers each year.

Demographic Characteristics of Follow-Up Respondents

The similarity between the two final study populations (respondents on whom telephone follow-up information was obtained) is shown in Table 1. There are essentially no differences in characteristics of the swimmers. The nonswimmers differ slightly with respect to more females, fewer teenagers, more older persons, and more nonwhite the second year.

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TABLE 1. DEMOGRAPHIC CHARACTERISTICS OF SWIMMERS AND NONSWIMMERS IN TELEPHONE FOLLOW-UP SAMPLE BY STUDY YEAR (IN PERCENT)

	Summer 1977		Summer 1978	
	Swim N=2649	Nonswim N=1131	Swim N=2901	Nonswim N=1179
Total	100.0	100.0	100.0	100.0
Sex: Male	54.0	40.3	51.7	35.5
Female	46.0	59.7	48.3	64.5
Age: Under 10	25.5	16.2	27.5	15.2
10 - 19	36.7	20.9	34.3	14.4
20 - 39	32.2	47.7	34.0	56.0
40 and over	4.9	14.2	3.7	13.4
not reported	0.7	1.0	0.5	1.0
Race/Ethnic:				
White	80.0	80.8	80.3	71.5
Black	11.1	11.8	9.5	15.0
Hispanic	6.2	5.6	5.7	8.6
Other	2.1	0.8	2.6	3.1
not reported	0.9	1.1	1.9	1.9
Socioeconomic:				
(Persons/room)				
Low: ≥ 1.50	39.7	28.9	41.7	32.1
Mid: 1:00 - 1.49	37.0	39.8	35.4	39.1
High: < 1:00	17.9	26.2	16.0	23.7
not reported	5.4	5.1	6.9	5.0

Reported Symptoms

Table 2 shows the rates of reported symptoms for swimmers and nonswimmers for the two years. There are several noteworthy differences and similarities. 1) All rates for swimmers, with the exception of skin rash, are lower the second year. All rates for nonswimmers, with the exception of vomiting, diarrhea, and skin rash, are down the second year. 2) Nonswimmer rates decreased proportinately more than the swimmer rates. This disproportionate relative change contributes to the finding of significant differences between swimmers and nonswimmers for more symptoms the second year. 3) With the exception of vomiting, symptoms which differentiated the two groups the first year also differentiated them the second year. Further, except for stomachache, there was no significant change in the rates for these differentiating symptoms the second year. 4) The rates which differentiated the second year but not the first were principally for respiratory symptoms (sore throat, cough, runny or stuffed nose, earache). 5) In 1978, but not 1977, the disabling rates for swimmers who stayed home or in bed because of symptoms were significantly higher than those for nonswimmers. However, both these rates were

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TABLE 2. REPORTED SYMPTOM RATES FOR SWIMMERS AND NONSWIMMERS, 1977 AND 1978[a]

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Symptom	Rate/1000 in 1977 Swim	Rate/1000 in 1977 Nonswim	Rate/1000 in 1978 Swim	Rate/1000 in 1978 Nonswim
Gastrointestinal:				
Vomiting	22**	9	21	14
Diarrhea	58**	22	50**	26
Stomachache	59**	39	37*	22
Nausea	34	25	30*	17
Respiratory:				
Sore throat	68	61	43*	25
Bad cough	48	42	28*	14
Chest cold	32	28	18	13
Eye, Ear, Nose:				
Runny or stuffed nose	58	58	41**	21
Earache or runny ears	30**	10	22**	6
Red, itchy or watery eyes (more than 1 day), styes	21	18	16	10
Other:				
Fever(more than 100° F)	30	31	22	18
Headache(more than few hours)	44	39	31*	19
Backache	16	16	7	4
Nonspecific:				
Skin rash, itching skin, welts	24*	13	27*	14
Sneezing, wheezing, tight chest, breathlessness (> 5 min.)	20	21	13	13
Disabling:				
Home because of symptoms	68	63	49**	31
In bed because of symptoms	52	45	41**	24
Medical help for symptoms	28	26	23	15

a These are unadjusted rates. The effects of adjusting on the basis of age, sex, ethnicity and persons/room ratio were minimal.

* Swimmer rate significantly higher than nonswimmer rate ($p < .05$)

** Swimmer rate significantly higher than nonswimmer rate ($p < .01$)

significantly lower in 1978 for swimmers and nonswimmers. The proportion who sought medical help did not change significantly from one year to the next and in neither year was there a significant difference in the rates for swimmers and nonswimmers.

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When rates are examined by symptom categories, i.e., one or more reported symptom in the category, the same pattern change is noted in the comparison of the results for the two years (Table 3). Rates for both swimmers and nonswimmers are lower the second year, nonswimmer rates are disproportionately lower, and the swimmer-nonswimmer rate differential is statistically significant for more symptom categories the second year.

TABLE 3. SYMPTOM CATEGORY RATES FOR SWIMMERS AND NONSWIMMERS, 1977 and 1978

Symptom Category[a]	Rate/1000 in 1977 Swim	Nonswim	Diff.	Rate/1000 in 1978 Swim	Nonswim	Diff.
Gastrointestinal (1 or more)	101	59	42**	86	47	39**
Respiratory (1 or more)	99	90	9	71	39	32**
Eye, Ear, Nose (1 or more)	92	76	16	69	37	32**
Other (1 or more)	73	65	8	53	30	23**
Nonspecific (1 or more)	48	37	11	38	27	11
Disabling (1 or more)	85	69	16	62	37	25**
Highly credible G.I.[b]	40	15	25**	35	19	16**
Disabling G.I.[c]	38	26	12	33	15	18**

a For specific symptoms in a category, see Table 2

b All instances of (1) vomiting, (2) diarrhea with fever or a disabling response, or (3) nausea and stomachache with fever

c 1 or more gastrointestinal symptoms and a disabling response

** Swimmer rate significantly higher than nonswimmer rate ($p < .01$)

These results lead one to question whether there are differences in a number of environmental conditions the two years which could have effected the observed rates. An indicator of one condition is the background symptom rate each year, i.e., rates of symptoms reported for the week prior to the weekend at the beach. For gastrointestinal symptoms the rates did not differ by year; between two to four percent of swimmers and nonswimmers each year reported gastrointestinal symptoms the previous week. In 1977 approximately nine percent and in 1978 approximately six percent of both groups each year reported some previous respiratory symptom. Thus, each year beachgoers, both swimmers and nonswimmers, experienced a significantly higher incidence

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of gastrointestinal symptoms than they had the previous week. In neither year did swimmers show an increase in respiratory symptom rates over the background rate; but in 1978 a lower respiratory symptom rate was reported by nonswimmers the week following their day at the beach.

Although swimmers in 1978 who reported gastrointestinal or respiratory symptoms the previous week were significantly more likely to report the same type symptom the week following swimming than those who had no previous symptoms, the effect of previous illness was minimal on the overall post-swim rate. Removal of those who reported like symptoms the previous week reduced the swimmer rate from 86/1000 to 82/1000 for gastrointestinal symptoms and from 71/1000 to 64/1000 for respiratory symptoms. For nonswimmers there was no significant association between pre- and post-beachgoing reports of gastrointestinal symptomatology, but those with previous respiratory symptoms were more likely to report similar symptoms the following week. As for swimmers, this had minimal effect on the overall rates when the previously ill were removed from the calculation. The change in gastrointestinal rates was from 47/1000 to 45/1000 and for respiratory symptoms from 39/1000 to 34/1000. Statistical significance of the swimmer/nonswimmer differential was obtained for both the uncorrected and the corrected rates. Additionally, illness did not distinguish those who swam from those who did not. Approximately 94 percent of nonswimmers specifically stated that illness was not the reason for their not going in the water.

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Gastrointestinal symptoms and respiratory symptoms were largely independent of each other. Of those persons who reported either or both type symptoms for the first year, only 25 percent of the swimmers and 14 percent of the nonswimmers reported both type symptoms. In that year more swimmers reported only gastrointestinal symptoms (41 percent) and more nonswimmers reported only respiratory symptoms (56 percent). In the second year only 12 percent of swimmers and 15 percent of nonswimmers reported both type symptoms, and more of both groups reported only gastrointestinal symptoms, 49 and 48 percent, respectively.

Symptoms by Demographic Characteristics

To determine whether the swimmer-nonswimmer differential symptom rates were attributable to specific subgroups within the populations observed, symptom rates were calculated for the several demographic categories. The results for Summer 1977 are shown in Table 4 and for Summer 1978 in Table 5.

In 1977 the only symptom categories showing significant swimmer-nonswimmer differential rates were gastrointestinal symptoms and eye, ear, or nose symptoms. The rates differed for both sexes, for all age groups except persons 20-39 years, for white but not nonwhite race/ethnic groups, and for those at the middle socioeconomic level as measured by the persons/room ratio. Eye, ear, or nose symptoms differed significantly between swimmers and nonswimmers only for women and persons in the middle level socioeconomic group. For the particular subgroups in which differences were not significant for gastrointestinal symptoms, the swimmer rates tended to be lower and the nonswimmer rates higher than the overall rates. The exceptions are Hispanic and "other (principally Vietnamese) ethnic groups for whom the

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TABLE 4. SYMPTOM CATEGORY RATES BY DEMOGRAPHIC CHARACTERISTICS FOR SWIMMERS AND NONSWIMMERS, RATE/1000 IN SUMMER 1977

	System Category											
	G.I.		Resp.		Other		EEN		Non-Spec.		Disabling	
Characteristic[a]	Sm	NSm	Sm	NSm	Sm	NSm	Sm	NSm	Sm	NSm	Sm	NSm
Sex: Male	100**	39	88	81	69	59	86	70	44	44	75	66
Female	103	74	114	95	79	70	100*	79	53	31	96	71
Age: 0 - 9	123**	50	119	128	70	78	108	106	55	30	107	111
10 - 19	108*	63	95	131	73	84	89	106	42	42	78	76
20 - 39	85	76	97	76	81	69	91	67	52	43	78	65
40+	63**	6	47	31	31	12	39	31	31	6	55	19
Race/Ethnic:												
White	108**	60	102	88	75	66	93	76	49	36	84	63
Black	88	83	75	76	44	61	68	61	41	15	78	98
Hispanic	68	32	106	143	92	95	124	79	37	95	104	63
Other	18	0	71	0	54	0	18	222	71	0	54	111
Socio-Econ: (persons-room)												
Low: ≥ 1.50	96	81	91	90	72	72	85	81	51	42	75	87
Mid: 1.00-1.49	110**	29	115	90	69	57	93*	59	43	29	97	66
High: < 1.00	101	87	101	100	88	80	111	104	61	43	88	57

[a] See Table 1 for percentage distributions in these categories

* Swimmer rate significantly higher than nonswimmer rate ($p < .05$)

** Swimmer Rate significantly higher than nonswimmer rate ($p < .01$)

TABLE 5. SYMPTOM CATEGORY RATES BY DEMOGRAPHIC CHARACTERISTICS FOR SWIMMERS AND NONSWIMMERS, RATE/1000 IN SUMMER 1978

Characteristic[a]	Symptom Category G.I. Sm	G.I. NSm	Resp. Sm	Resp. NSm	Other Sm	Other NSm	EEN Sm	EEN NSm	Non-Spec. Sm	Non-Spec. NSm	Disabling Sm	Disabling NSm
Sex: Male	75	48	62*	32	45	29	69*	36	29	27	58	39
Female	97**	46	80**	43	60**	30	69**	37	46*	26	66**	36
Age: Under 10	118*	67	68	50	52	45	64	68	35	40	88	45
10 - 19	83*	36	86	58	56	65	85	53	41	65	56	65
20 - 39	70*	46	62*	38	54**	23	64**	30	38	23	51*	31
40 & over	19	44	28	13	19	6	10	13	19	6	19	19
Race/Ethnic:												
White	91**	53	70*	45	54**	30	71**	40	39	32	63*	41
Black	58	28	72*	28	58	23	80*	28	40	11	55	28
Hispanic	60	30	85	31	36	40	43	30	24	20	72	20
Other	14	56	27	0	14	0	14	0	27	0	14	0
Socio-Econ.: (persons/room)												
Low: $\geq$ 1.50	81**	34	63	37	45*	21	59**	24	26	13	62*	32
Mid: 1.00-1.49	95**	50	77*	46	64*	33	79**	41	51	35	65**	26
High < 1.00	91	64	98**	40	63	43	96*	50	52	36	74	69

[a]See Table 1 for percentage distributions in these categories

*Swimmer rate significantly higher than the nonswimmer rate ($p < .05$)

**Swimmer rate significantly higher than the nonswimmer rate ($p < .01$)

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rates were low in both swimming categories. There were very few cases in each of these groups. Low and high socioeconomic levels showed swimmer gastrointestinal rates essentially the same as the overall rate but the nonswimmer rates were higher than the overall rate for nonswimmers.

For 1978, the pattern of swimmer-nonswimmer differences by demographic characteristics for gastrointestinal symptoms differs only slightly from that observed the previous year. Female swimmers differed significantly from female nonswimmers but the difference for males was not significant. Swimmer rates were significantly higher than nonswimmer rates for all age groups except those age 40 or over for whom the nonswimmer rate was higher but not significantly so. Again a significant difference was noted only for whites. Black and Hispanic groups had rates lower than the overall rate in both swimming categories, but the nonswimmer rate for the "other" race/ethnic group exceeded the swimmer rate. Again the number of cases was small. In 1978 both the low and middle socioeconomic groups showed a significant swimmer-nonswimmer differential for gastrointestinal symptoms. The high group again showed elevation of the nonswimmer rate.

For the remaining symptom categories, swimmer-nonswimmer differences appear to be attributable principally to differences for females, persons age 20-39, whites (who comprise more than three-fourths of the population) and persons in the low and middle socioeconomic groups. Noteworthy is the finding that for children under age 10, the swimmer-nonswimmer differential is statistically significant only for gastrointestinal symptoms.

As might be anticipated from the presentation of the overall rates, the magnitude of the rates the second year is lower than the first year, but general patterns by demographic characteristics can be observed. In all symptom categories, rates for females are slightly higher than for males, nonswimmer rates for young children and those 10-19 are considerably above the overall nonswimmer rates for each symptom category, both swimmer and nonswimmer rates in the other age categories are lower than overall rates, and rates for persons in the higher socioeconomic level are higher than for those in the two defined lower levels.

Symptomatology by Age

The markedly higher gastrointestinal rate for young swimmers each year led to examination of specific symptoms by age to determine whether the types of symptoms were the same for adults and children and whether the order of the specific symptoms was the same both years. The results are presented in Table 6.

In the first year diarrhea and stomachache were the major complaints among children who swam. In the second year the same was true, but for no single complaint did the rate differ significantly between swimmers and nonswimmers. Diarrhea was reported significantly more frequently for older swimmers than nonswimmers both years, and in the second year a significantly higher number of older swimmers than nonswimmers reported nausea. Essentially the specific symptom patterns are the same for the two years. The swimmer-nonswimmer differential rate for highly credible gastrointestinal

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TABLE 6. RATES OF SPECIFIC AND COMBINED GASTROINTESTINAL SYMPTOMS, HIGHLY CREDIBLE G.I. SYMPTOMS, AND DISABLING INDICATORS BY AGE FOR SWIMMERS AND NONSWIMMERS, RATE/1000 IN SUMMERS, 1977 AND 1978

Symptom/Category	Rate/1000 in 1977				Rate/1000 in 1978			
	Under 10		10 & over		Under 10		10 & over	
	Sm (675)	Nsm (180)	Sm (1958)	Nsm (935)	Sm (800)	Nsm (179)	Sm (2086)	Nsm (988)
Vomiting	36	22	18**	6	35	22	16	16
Diarrhea	85**	22	49**	22	68	39	44**	24
Stomachache	74**	28	52	39	58	28	29	21
Nausea	34	33	33	23	28	11	37**	18
Combined G.I.	123**	50	94**	61	118*	67	73**	44
Highly Credible G.I.	61*	28	33**	12	59	28	26	17
Fever	56	66	20	25	38	39	16	14
Stayed home	90	106	61	55	72	34	41	31
Stayed in bed	62	78	49	39	55	23	35	25
Sought medical help	43	61	23	19	40	23	16	12
Combined disabling	107	111	76	60	88	45	52*	35
Disabling G.I.	54	34	32	24	58*	17	23	14

*Swimmer rate significantly higher than nonswimmer rate ($p < .05$)
**Swimmer rate Significantly higher than nonswimmer rate ($p < .01$)

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symptoms was statistically significant for both age groups the first year but not the second, although the order of the differences was similar for the two years. Disabling gastrointestinal symptoms the second year were significantly higher ($p < .05$) for young swimmers but not the first year. The difference is largely attributable to a reduction in the rate for young nonswimmers the second year. Essentially the specific symptom patterns are the same both years.

The gastrointestinal symptoms were of short duration in most cases. For cases of vomiting among swimmers, more than 60 percent reported the symptom occurred and lasted no more than one day; only one-third of the nonswimmers reported this short duration. Diarrhea lasted longer among nonswimmers; more than half of nonswimmers and only one-third of swimmers reported bouts of three or more days duration. Stomachache and nausea had disappeared after two days for approximately 70 percent of both swimmers and nonswimmers.

In Summer 1977 there was no difference in the rates of respiratory symptoms reported by swimmers and nonswimmers by age. Further, the rates reported the week after swimming did not differ by age or swimmer category from the rates reported for the week prior to swimming. The overall respiratory symptom rates for the week prior to swimming and the week after swimming were 93/1000 and 99/1000, respectively, for swimmers and 91/1000 and 90/1000, respectively, for nonswimmers.

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In Summer 1978 the respiratory symptom rate the week prior to swimming was significantly lower than the previous year, 60/1000 compared to 95/1000 in 1977, and this rate was approximately the same for younger and older swimmers and nonswimmers. There was a significant difference in the rates for respiratory symptoms the week following swimming reported by the older swimmers. The rate reported for swimmers and nonswimmers under age 10 (58/1000 and 51/1000 , respectively) did not differ significantly from each other or from the rates for these symptoms reported for the previous week (54/1000 and 67/1000, respectively). The rate reported for older swimmers the week following swimming (72/1000) did not differ from the rate for the previous week reported for all persons (61/1000), but it did differ from the post-beach rate for older nonswimmers (38/1000). For older nonswimmers this rate was significantly lower than their rate for the week prior to being at the beach. This pattern of differences was obtained even when the rates were controlled for those who had symptoms the previous week. The data are shown in Table 7. It can be seen that the trend is the same for young children although the difference for that age group is not statistically significant.

Perpetuation of symptoms from the previous week had little effect either year. The percentage of swimmers and nonswimmers who reported respiratory symptoms both before and after being at the beach in 1978 were 20 percent and 11 percent for those under age 10, and 14 percent and 20 percent for those 10 and over. The percentages, much the same in 1977, do not differ statistically.

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Weather Conditions

The climate in New Orleans in summer is characterized by heat, humidity, and scattered thunderstorms. The only variation by month tends to be the amount of actual precipitation. Despite the fact that beach interviewing was begun one month earlier the second year, there was very little variation in climatological conditions the two years. The average maximum temperature on the 14 trial days in 1977 was 92.3° F, ranging between 86° and 96° F; for the 12 trial days in 1978, the mean maximum was 91.5° F, ranging between 89° F and 94° F. Minimum temperature never went below 72° F, and average dew point was mid-70 each year. Wind speeds varied between 0.6 and 8.7 mph each year and were about equally divided between a southeasterly and southwesterly direction. Using "percent of possible sunshine" as an indicator of cloud cover, on six of the 14 trial days in 1977 and on five of the 12 trial days in 1978, the percentage was less than 60 (8). For each year there were a few days on which brief showers occurred at the beach, causing people either to leave or to take cover temporarily. In terms of cumulative rainfall prior to the trial weekends, conditions were much the same for all weekends of 1978 and the first five of the eight weekends in 1977; the cumulative amount of precipitation was less than one inch. August 1977, however, was the wettest month in over 80 years. Although the weekends were generally fair in this month (only one Sunday was rained out), comparatively few interviews were obtained and symptom rates varied as much as during the previous five weekends.

Water Quality

The principal difference in the research experience over the two years was the water quality as measured by the microbial indicators used. The day-to-day and even hour-to-hour variation in the microbial levels observed in 1976 pretesting remained the first year. There were a number of days and times when microbial counts were low, and a number when they were exorbitantly high (Appendix A). There was no reason to suspect that similar conditions would not exist the following summer.

The second year, however, water quality differed radically. Whereas in the Summer 1977 *E. coli* levels had reached the magnitude of several thousand organisms per 100 ml., in 1978 levels for this indicator never exceeded 500/100 ml. and generally were below 100/100 ml. Enterococcus levels, which had ranged between zero and 3400/100 ml. the first year, ranged between zero and 1267/100 ml. the second year. In 1977 only 13 percent of the samples taken yielded an enterococcus count below 25/100 ml.; in 1978 counts below this level were obtained in 46 percent of the sample (Appendix B).

In 1977, the geometric mean recovery of *E. coli* for all samples (N=42) was 473/100 ml. in the roped area and 667/100 ml. in the bayou area. In 1978 the corresponding means (based on 24 samples) were 52/100 ml. and 72/100 ml. Enterococcus levels were reported with a geometric mean of 56/100 ml. and 148/100 ml. for the two locations in 1977 and 24/100 ml. and 35/100 ml. in 1978.

The first summer an inverse relationship was noted between *E. coli* and enterococcus levels. The rank order correlation of the geometric mean on

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TABLE 7. GASTROINTESTINAL AND RESPIRATORY SYMPTOM RATES THE WEEK PRIOR AND THE WEEK FOLLOWING BEING AT THE BEACH FOR SWIMMERS AND NON-SWIMMERS BY AGE, 1977 AND 1978

Age/Swim Category	Rate/1000 in 1977						Rate/1000 in 1978					
	Gastrointestinal			Respiratory			Gastrointestinal			Respiratory		
	Prev. Week	Week After	Adj. Rate*	Prev. Week	Week After	Adj. Rate*	Prev. Week	Week After	Adj. Rate*	Prev. Week	Week After	Adj. Rate*
Under age 10:												
Swimmers	31	123	112	90	119	103	29	118	116	54	68	57
Nonswimmers	44	50	41	100	128	123	28	67	57	67	51	48
Age 10 and over:												
Swimmers	27	93	91	94	93	81	20	74	72	64	72	66
Nonswimmers	32	61	60	89	82	65	19	44	43	56	38	31

*Rate when those with symptoms the previous week are removed from the calculation.

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trial days for these two indicators was negative .70 for the roped area and negative .35 for the bayou area. In 1978 there was a positive rank order correlation of .65 at each location.

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The geometric means by trial day for E. coli and enterococci by swimming location are presented in Tables 8 and 9. Also presented are the standard scores based on the geometric mean and standard deviation of all samples taken each year. The z scores were plotted (Figure 1) for graphical display of the relationship each year. For simplicity of presentation only the results of the roped area are depicted. The findings for the bayou area are similar.

TABLE 8. GEOMETRIC MEAN RECOVERY OF E.COLI AND ENTEROCOCCI BY TRIAL DAY AND LOCATION, SUMMER 1977 (ORGANISMS/100 ML.)

	Geometric Mean				Standard Score (z)*			
	E. coli		Enterococci		E. coli		Enterococci	
Trial Day[a]	Roped area	Bayou area	Roped area	Bayou area	Roped area	Bayou area	Roped area	Bayou area
1	64	765	136	446	-.20	.06	.44	1.56
2	32	90	228	273	-.22	-.33	.95	.65
3	33	147	315	114	-.22	-.30	1.43	-.18
4	241	92	632	90	-.16	-.33	3.18	-.30
5	155	80	169	699	-.16	-.34	.62	2.89
6	4336	2650	34	40	1.93	1.15	-.12	-.57
7	597	518	17	40	.06	-.09	-.21	-.57
8	3930	4632	11	311	1.72	2.30	-.25	.85
9	858	1173	18	211	.19	.29	-.21	.34
10	5676	3359	34	45	2.60	1.56	-.12	-.54
11	650	280	63	56	.09	-.22	.04	-.48
12	1657	3481	3	9	.59	1.63	-.29	-.72
13	531	2942	11	77	.03	1.32	-.25	-.37
14	350	625	62	125	-.06	-.02	.03	-.12
Mean of all samples	473	667	56	148	Standard error of the mean: 2005.	1726.	181.	191.

* $z = \frac{\text{Trial Day Mean - mean of all samples}}{\text{standard error of the mean}}$

[a]Trial days are grouped by weekends.

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TABLE 9. GEOMETRIC MEAN RECOVERY OF E. COLI AND ENTEROCOCCI BY TRIAL DAY AND LOCATION, SUMMER 1978 (ORGANISMS/100 ML.)

Trial Day[a]	Geometric Mean: E. coli, Roped area	E. coli, Bayou area	Enterococci, Roped area	Enterococci, Bayou area	Standard Score (z)*: E. coli, Roped area	E. coli, Bayou area	Enterococci, Roped area	Enterococci, Bayou area
1	341	387	39	9	2.92	2.94	.11	-.22
2	210	100	2	33	1.60	.26	-.16	-.02
3	28	78	9	120	-.24	.06	-.11	.76
4	105	141	14	120	.52	.64	-.08	.75
5	81	103	225	291	.29	.29	1.44	2.27
6	56	68	13	25	.04	-.04	-.08	-.09
7	61	36	65	35	.09	-.34	.29	.01
8	28	45	8	12	-.24	-.25	-.12	-.19
9	48	32	10	16	-.04	-.37	-.11	-.16
10	13	12	37	8	-.40	-.56	.09	-.25
11	6	25	5	3	-.46	-.44	-.14	-.28
12	66	222	460	298	.14	1.40	3.12	2.33
Mean of all samples	52	72	24	35	Standard error of the mean: 99.	107.	140.	113.

* See note to Table 8.

Symptomatology and Water Quality

Corroboration of the New York study findings at the "barely acceptable" site of a statistically significant difference between the rates of swimmers and nonswimmers for gastrointestinal symptoms in the New Orleans study the first year was encouraging for the hypothesis that these particular symptoms for swimmers are related to exposure to aquatic microbial density. The problem then was to determine how to measure exposure and, next, how to relate exposure to symptom rates. A number of methods were tried the first year, and the most promising ones were replicated in the analysis of the second year data.

Analysis by Trial Day--

Since microbial density tended to vary with the amount of rainfall, the first attempt was to classify trial days according to dry and wet weather conditions. Swimmers and nonswimmers were then distributed according to the condition on the trial day on which they were interviewed, and swimmer-nonswimmer gastrointestinal rates were tested for significance of difference under the dry and wet conditions. This was not productive either year. Some

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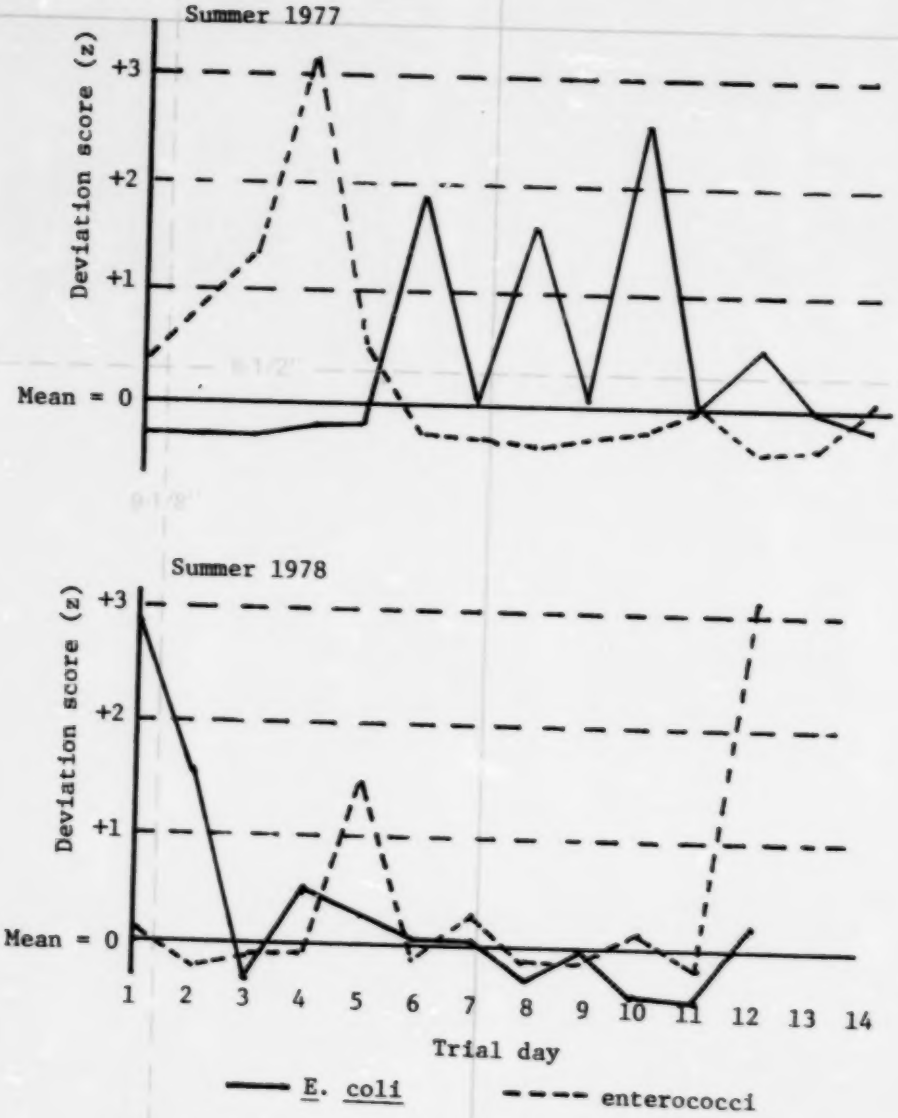
Figure 1. Deviation scores of trial day geometric mean recovery from the geometric mean of total number of trial days, roped area, Summer 1977 and 1978



The geometric means for E. coli for 1977 and 1978 were 473 and 52/100 ml., respectively. The corresponding means for enterococci were 56 and 24/100 ml.

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of the highest gastrointestinal symptom rates for swimmers occurred on days classified as dry weather and some of the lowest on days classified as wet. There was similar variation in nonswimmer rates by trial day. Further, in the first year study, although the geometric mean of E. coli and other indicators tended to show the expected positive correlation with rainfall, enterococcus counts did not. In addition, since there was a wide range in indicator density particularly on some days, part of a day but not the whole day satisfied the criterion under which the day was classified.

Rank Order of Indicator Densities by Trial Day and Location--

To overcome variability in indicator measurements by day and place, mean counts by day and location, roped or bayou area, were rank ordered for each of the indicators and for various combinations of the indicators. Swimmer-nonswimmer rate differences were then tested between the groups at the extremes of these distributions. No systematic association was found between symptom rates and indicator densities when arrayed in this way. This method also was limited in that it did not allow for within-day indicator density variation.

Exposure by Day, Time, and Place of Swimming--

Since the beach interview provided information regarding time of day as well as location of swimming, it was possible to link counts derived from the water samples taken closest to the time and location for each individual swimmer. In the event that a person swam across sampling times or in more than one location, the highest count was used as the indicator of exposure. Each swimmer, therefore, had an exposure measure on each microbial indicator. Symptom rates could then be calculated for various levels of exposure. The nonswimmer rate was constant, i.e., not related to day, time, or place. Results of analyses based on this individual exposure measure follow.

Gastrointestinal symptoms and E. coli/Enterococci exposure--Analysis using this methodology on the 1977 data indicated some progression of symptom rate with amount of exposure up to a certain level, especially with respect to E. coli and enterococci for gastrointestinal symptoms. Beyond that level, which may indicate a threshold, there was no marked increase in symptom rates. Symptom rates for swimmers exposed to low level densities of these two indicators did not differ from the rate for the nonswimmer controls. Persons swimming at E. coli levels of 200/100 ml. and above or at enterococcus levels of 25/100 ml. and above were found to have significantly higher gastrointestinal attack rates than nonswimmers and higher rates, though not at all levels significantly higher rates, than persons swimming at lower levels of exposure. Table 10 shows the order of these progressions for the 1977 data.

The findings for 1978 were less decisive. The results are shown in Table 11. (The microbial count categories are changed slightly to make the number exposed more equitable.) The progression of gastrointestinal symptom rate by E. coli count is in the expected direction but not significantly different by level. The gastrointestinal symptom rate for swimmers under E. coli conditions of 200/100 ml. or less is 86/1000 and for over 200/100 ml. is 96/1000. For increasing enterococcus levels there is no progression of gastrointestinal symptom rates using the Summer 1977 criterion of 25

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enterococcus organisms/100 ml. For differentiating low/high exposure conditions, the gastrointestinal rate under the low criterion was 89/1000 and under the high condition 87/1000.

Observing in the 1977 data the inverse relationship between E. coli and enterococcus levels, it was felt that these two indicators might operate differentially and that any independent effect would be obscured when the measures were examined singly. In other words, if exposure to relatively high densities of E. coli was associated with illness, and exposure to relatively high densities of enterococci were similarly associated, then the symptom rates for swimmers might be essentially the same for low and high densities of either indicator due to the effect of the other when analyzed in this way. This led to analysis of symptom rates using the two indicators in combination.

TABLE 10. GASTROINTESTINAL SYMPTOM RATES BY EXPOSURE TO E. COLI AND ENTEROCOCCI, SUMMER 1977

Nonswimmer Rate - 60/1000

E. coli			Enterococci		
Density: Organisms/ 100 ml	Number of Persons	Rate/1000	Density: Organisms/ 100 ml	Number of Persons	Rate/1000
0	46	65	0	44	68
1 - 100	547	104	1 - 50	725	89
101 - 200	173	81	51 - 100	275	138
201 - 400	458	142	101 - 200	237	89
401 - 500	408	83	201 - 400	536	110
>500	732	94	401 - 800	538	102

TABLE 11. GASTROINTESTINAL SYMPTOM RATES BY EXPOSURE TO E. COLI AND ENTEROCOCCI, SUMMER 1978

Nonswimmer Rate - 47/1000

E. coli			Enterococci		
Density: Organisms/ 100 ml	Number of Persons	Rate/1000	Density: Organisms/ 100 ml	Number of Persons	Rate/1000
0 - 50	840	67	0 - 25	1096	89
51 - 100	845	89	26 - 50	806	87
101 - 200	667	106	51 - 100	426	105
201 - 300	219	96	101 - 200	269	63
> 300	227	97	>200	201	80

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This form of analysis was used for the data from both years despite the fact that the inverse relationship between the two indicators did not obtain the second year. Since each year the attack rates were higher for children under 10 years of age, separate analyses were carried out for children and persons age 10 and over. The results are shown in Tables 12 and 13.

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From Table 12 it can be seen that for young swimmers in 1977: 1) the G.I. symptom rates differed from the nonswimmer rate only for those exposed to high E coli conditions; 2) the rates for the two E. coli conditions were the same, i.e., did not vary with a change in enterococcus levels; and 3) the rates for the two high E. coli conditions were significantly higher than the rate for the high enterococcus but low E. coli condition.

TABLE 12. GASTROINTESTINAL, HIGHLY CREDIBLE G.I., AND DISABLING G.I. SYMPTOM RATES BY SIMULTANEOUS EXPOSURE TO VARYING LEVELS OF E. COLI AND ENTEROCOCCI BY AGE

6 1/2" RATE/1000 IN SUMMER 1977

Age	Gastrointestinal			Highly Credible G.I.			Disabling G.I.		
	Non-swim	E. coli 0-200	E. coli >200	Non-swim	E. coli 0-200	E. coli >200	Non-swim	E. coli 0-200	E. coli >200
Under 10 years:	50			28			34		
Enterococci									
0 - 25		53	145[ab]		0	51		0	68[a]
> 25		76	148[ab]		30	89[ab]		12	75[ab]
10 years & over:	61			12			24		
Enterococci									
0 - 25		67	69		33	17		33	24
> 25		106[a]	96[a]		28[a]	38[a]		43	27

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[a] Significantly higher ($p < .05$) than nonwimmer rate

[b] Significantly higher ($p < .05$) than swimmer rate under conditions of high enterococci/low E. coli.

The rate patterns for the more stringent indicators of gastrointestinal symptoms, namely, highly credible G.I. symptoms and severe G.I. symptoms were less clear but still suggestive of a stronger association between E. coli level and G.I. symptoms than between enterococcus level and these symptoms. Only children who swam under conditions when counts for both microbial indicators were high showed a higher credible G.I. symptom rate than nonswimmers.

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This rate was not significantly different from that for swimmers under the high E. coli-low enterococcus conditions but was significantly higher than the rate for low E. coli-high enterococcus condition. The findings using rates for disabling G.I. symptoms were the same as for highly credible G.I. symptoms with the additional finding that the rate for the group swimming when only E. coli count was high was significantly higher than the rate for those swimming under the condition when only the enterococcus count was high.

TABLE 13. GASTROINTESTINAL, HIGHLY CREDIBLE G.I., AND DISABLING G.I. SYMPTOM RATES BY SIMULTANEOUS EXPOSURE TO VARYING LEVELS OF E. COLI AND ENTEROCOCCI BY AGE
RATE/1000 IN SUMMER 1978

Age	Gastrointestinal			Highly Credible G.I.			Disabling G.I.		
	Non-swim	E. coli 0-200	E. coli >200	Non-swim	E. coli 0-200	E. coli >200	Non-swim	E. coli 0-200	E. coli >200
Under 10 years:	67			28			45		
Enterococci:									
0 - 25		129[a]	82		48	17		48	50
>25		119	114		70[a]	86		68	57
10 years & over:	44			17			35		
Enterococci:									
0 - 25		73[a]	97[a]		27	7		20	28
>25		74[a]	75		25	67[ab]		23	38

[a] Significantly higher ($p < .05$) than nonswimmer rate

[b] Significantly higher ($p < .05$) than swimmer rates in the other three cells of the square

When these rates for swimmers under 10 were subjected to analysis exploring the effect of each microbial indicator controlling for the other,* i.e., removing the effect of each indicator and testing for the effect of the other, the association between E. coli and each of the three classifications of symptoms is quite clear. After the removal of the effect of E. coli there is no significant dependence of the rates on enterococci; whereas, after removing the effect of enterococci the rates are significantly ($p < .01$) associated with E. coli.

* Analysis of Multidimensional Contingency Tables by Log-Linear Models

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Analysis of the 1978 data in this way for young children revealed no association with indicator levels taken either singly or in combination. Although the overall swimmer rate differed significantly from the nonswimmer rate for the general category of gastrointestinal symptoms, when this rate was partialled according to exposure categories, only the rate for those exposed at low levels of both indicators differed from the nonswim rate. The swimmer rates for each cell were approximately the same.

Rates for highly credible G.I. symptoms and disabling G.I. symptoms for children exposed at low levels of E. coli in 1978 were considerably higher than those noted in 1977. But for these symptom categories as well, there was no significant difference among rates within the cells.

For older swimmers, age 10 and over, the values shown in Table 13 for the 1977 data suggest that enterococcus densities are more strongly associated with gastrointestinal symptomatology. Only under conditions when enterococcus counts were high did the swimmer rates differ from the nonswimmer rate. Analysis to observe the effect of each indicator independently, however, showed that after controlling for the effect of one indicator, the other is not significantly associated with the rates. In other words, although the swimmer-nonswimmer differential for general G.I. and highly credible G.I. symptoms was significant for persons who swam under either condition of high enterococcus level, other factors than the two microbial indicators observed appeared to contribute to this effect.

Second year data for older swimmers showed much the same pattern as for young swimmers with respect to general G.I. symptoms. Although the rates in more cells differed significantly from the nonswimmer rate, the rates in the four cells were essentially equivalent. Highly credible G.I. symptom rates for the four exposure categories, however, showed an elevation for swimmers exposed to simultaneously high levels of the two indicators. This rate differed significantly not only from the nonswimmer rate but from the rates in the other three cells of the table. No differences were noted among the rates for disabling G.I. symptoms. Although analysis revealed no significant effect for either indicator taken independently of the other, there was significant interaction effect of the two indicators with highly credible G.I. symptoms.

Respiratory symptoms and E. coli/enterococcus exposure--In the first year swimmers did not differ from nonswimmers with respect to respiratory symptoms, thus this symptom category was not explored further. In the second year there was a difference. It was noted that the swimmer rate did not differ from the background rate reported for the week prior to swimming; therefore, it did not seem likely that microbial exposure as a result of swimming would explain this difference. The mystery was why nonswimmers had fewer respiratory symptoms after being at the beach than they had before. Nevertheless, analysis of respiratory symptoms and exposure was carried out in the same manner as for gastrointestinal symptoms. The results for the two age groups for the two years are shown in Table 14.

In 1977 the nonswimmer rate for respiratory symptoms in young children slightly exceeded the swimmer rate for each indicator exposure category. The higher rates noted for swimmers under conditions of high enterococcus levels

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did not differ significantly from the rates under other exposure conditions. In 1978, however, respiratory symptom rates for young swimmers exposed to high E. coli conditions differed significantly from those exposed to low E. coli conditions at the .04 level of confidence, and this E. coli effect appeared to be independent of any enterococcus effect (.057 confidence level).

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For older swimmers in 1977 significantly higher respiratory symptom rates were obtained for those exposed to high levels of enterococci than low levels of this indicator and this effect appeared to be independent of the E. coli level. This pattern was observed for gastrointestinal symptoms in 1977 but the differences were not statistically significant. In 1978 the rates for respiratory symptoms were equivalent for all exposure categories, hence no apparent microbial effect.

TABLE 14. RESPIRATORY SYMPTOM RATES BY SIMULTANEOUS EXPOSURE TO VARYING LEVELS OF E. COLI AND ENTEROCOCCI BY AGE, SUMMERS 1977 AND 1978

6-1/2"

	Rate/1000 in 1977			Rate/1000 in 1978		
	Non-swim	E. coli 0-200	E. coli >200	Non-swim	E. coli 0-200	E. coli >200
Under 10 years:	128			50		
Enterococci:						
0 - 25		0	94		65	148[ab]
>25		124	124		61	86
10 years & over:	82			37		
Enterococci:						
0 - 25		33	52		61[a]	90[a]
>25		101[c]	102[c]		76[a]	75[a]

[a] Significantly higher ($p < .05$) than nonswimmer rate

[b] Significantly higher ($p < .05$) than the swimmer rates in the other three cells of the square

[c] Significantly higher ($p < .01$) than swimmer rates under both low enterococcus condition

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The Control Site

In the second year the study was extended to a bathing area on the northern side of Lake Pontchartrain where the water is less polluted, Fontainebleau State Park. Four weekend trials were conducted between June 24 and July 17. Study conditions were not comparable to those at Levee Beach. Fewer people used the site and almost half of those who swam there were ineligible because of previous midweek swimming or swimming elsewhere on the same day. (There is a swimming pool in the park.) Of the 551 respondents, only 45 percent were swimmers, 69 percent were black, and 48 percent of the swimmers were children.

There were no significant differences in symptom rates for swimmers and nonswimmers with the exception of eye-ear-nose symptoms. Overall swimmer rates were essentially the same as those for swimmers at Levee Beach; nonswimmer rates tended to be higher than the Levee Beach rates. When these rates were calculated by age, however, the swimmer rates for children were considerably lower than rates for children at Levee Beach, especially for combined gastrointestinal symptoms. For children under ten this rate was 55/1000 for swimmers and 89/1000 for nonswimmers. The rates for the older age group were 101/1000 and 57/1000, respectively.

Water conditions differed markedly at the two sites (Appendix B). E.coli counts ranged between 1 and 21/1000 ml. (mean of 16/1000) and enterococcus counts between 0 and 325/100 ml. (mean of 41/100 ml.). Thus no swimmers were exposed to high densities of E. coli but some were exposed to high densities of enterococci. Under these conditions the findings of a low gastrointestinal symptom rate for children and a considerably higher rate for older swimmers tends to corroborate the findings with respect to an enterococcus effect commented on earlier.

DISCUSSION

Interviewing results indicated that there was no change in the populations using the Lake Pontchartrain Beach each year. Sociodemographically the two groups of respondents on whom information was collected for the analysis of health effects by year were remarkedly similar. Also from a demographic point of view, no bias was apparent due to failure to follow-up. On this basis it is reasonable to assume that reported symptom rates were representative for the total population at the beach during the periods of observation.

The finding of lower symptom rates for both swimmers and nonswimmers the second year suggests that there was less illness in New Orleans generally that summer. However, rates for symptom categories reported retrospectively for the week prior to swimming were much the same each year, except for respiratory symptoms which were significantly lower the second year. The proportionately lower rates for nonswimmers than swimmers the second year compared to the first year tends to support the notion of a somewhat healthier climate the second year and the hypothesis that symptoms for swimmers were water related.

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However, gastrointestinal symptoms in swimmers the second year were not associated with water quality in the same way as appeared to be the case the first year. The strong association between exposure to E. coli as measured in this study and G.I. symptoms in young children which was found the first year was in no way apparent the second year. The suggested but not statistically documented association of enterococcus level and G.I. symptoms in swimmers age 10 and over noted the first year was again suggested the second year; however, in the second year there appeared to be an interaction effect of the two indicators rather than a possible independent association of enterococci.

The association between enterococcus densities and respiratory symptoms for older swimmers the first year and between E.coli density and respiratory symptoms for young swimmers the second year is difficult to comprehend. These symptoms as reported by respondents tended to be independent, i.e., respondents tended to report either one or the other type symptom with a very small percentage reporting both. Therefore, in the analyses of exposure with gastrointestinal and with respiratory symptoms illness is being reported for different persons. Further analyses can be done controlling for perpetuation of previous symptoms and combinations of the two type symptoms to see if the relationships between indicators and these symptom categories still hold for those subgroups in which they were found.

The exposure analyses suffered each year from a small number of cases in some of the cells, especially for young swimmers. The first year almost too few were exposed to low levels of the indicators and the second year few at the higher density levels. This was unfortunate but beyond the control of the researchers.

Factors accounting for the difference in water quality the two years are difficult to assess. To our knowledge there was no change in sewage disposal procedures in either Orleans or Jefferson Parish. The variation in rainfall prior to weekend trials was essentially the same the two years except for the last two trial weekends the first year when rainy conditions precluded a large beach turnout and consequently few persons were interviewed for a report on symptoms. A unique event occurred in May the second year, approximately six weeks prior to initiation of beach interviewing, when almost ten inches of rain fell in a matter of a few hours, and storm water runoff was pumped at a rapid rate through the canals into the lake. It is conceivable that this deluge had the effect of thoroughly laundering the city and the canals. Whether this explanation is consistent with viability of the organisms is questionable.

The inverse relationship between E. coli and enterococcus densities noted the first year was not corroborated the second year. The greatest change in the density magnitude from one year to the next was for E. coli. To the extent that high E. coli counts are associated with storm water runoff into the lake resulting in a dilution effect, then enterococci density may be lower in the samples taken. Under more normal conditions, as in places with less pollution variation, density of these two indicators tend to vary together.

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Both years both E. coli and enterococci densities were somewhat higher at the mouth of Bayou St. John. According to the New Orleans Sewerage and Water Board, the Bayou has been dammed at a point perhaps a quarter of a mile from the mouth so that there is no flow out. On this basis the higher counts might be attributable to a slower flow in this cove-like situation than occurs on the actual lake shore.

In general the findings of the New Orleans studies both years are consistent with the New York study results, especially with respect to swimmer-nonswimmer symptom rate differentials, the sociodemographic subcategories in which significant differences are most likely to occur, and the short duration of the symptoms. Although the studies at both sites suggest E. Coli as a criterion indicator of health effects for swimming in marine waters, especially for young swimmers, the different procedures for measuring exposure to the indicators at the two sites makes one wish for somewhat more precise replication. Since the New Orleans situation, for environmental reasons, could not replicate the two-pollution-level site design of the New York study, the question is raised whether the exposure measures used in New Orleans could be applied to the New York data. On this basis it might be easier to develop a mathematical model for testing relationships in other sites.

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REFERENCES

1. Cabelli, V.J., Dufour, A.P., Levin, M.A., McCabe, L.J., and Haberman,P.W. Relationship of microbial indicators to health effects at marine bathing beaches. Am. J. Public Health, 69:690-696, 1979.

2. Cabelli, V.J., Dufour, A.P., Levin, M.A., and Haberman, P.W. The impact of pollution on marine bathing beaches: An epidemiological study. In: Middle Atlantic Continental Shelf and the New York Bight. Limnol and Oceono Sp Symp, 2:242-432, 1976.

3. Stevenson, A.H. Studies of bathing water quality and health. Am. J. Public Health, 43:529-538, 1953.

4. Dufour, A.P., Strickland, E.R., and Cabelli, V.J. Enumeration method for thermotolerant E. coli. Proceedings of the 9th National Shellfish Sanitation Workshop, Food and Drug Administration - Shellfish Sanitation Branch, pp. 79-81.

5. Levin, M.A. and Cabelli, V.J. Membrane filter technique for enumeration of Pseudomonas aeruginosa. J. Appl. Microbiol, 24:864-870, 1972.

6. Levin, M.A., Fisher, J.R., and Cabelli, V.J. Membrane filter technique for enumeration of enterococci in marine waters. J. Appl. Microbiol, 30:66-71, 1975.

7. American Public Health Association: Standard Methods for the Examination of Water and Wastewater. 14th ed. American Public Health Association, Inc., New York, 1975.

8. National Weather Service Meteorological Observatory: Local Climatological Data. Monthly Summary, New Orleans, La. National Oceanic and Atmospheric Administration, Environmental and Data Information Service, June, July, August 1977 and June, July 1978.

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BOTTOM OF IMAGE AREA; OUTSIDE DIMENSION FOR TABLES AND ILLUSTRATIONS
3/8"

EPA-287 (Cin.)
(4-76)

APPENDIX A-1. WATER SAMPLING RESULTS: ROPED-OFF AREA, SUMMER 1977
(organisms per 100 ml.)

Time	Trial Date 7/9	7/16	7/17	7/23	7/24	7/30	7/31	8/6	8/7	8/13	8/14	8/20	8/27	8/28
	E. coli													
12	0	16	23	470	40	18750	960	5030	930	10700	660	1900	1067	260
2	360	18	36	230	233	4830	370	2700	660	6260	660	1800	300	460
4	730	117	43	130	400	900	600	4470	1030	2730	630	1330	467	360
	Klebsiella													
12	30	4	3	200	67	4500	200	1070	360	1550	260	1900	1160	130
2	100	2	16	130	53	1370	100	1130	330	1360	200	1160	260	100
4	70	10	10	60	133	700	170	1400	400	630	200	1830	460	130
	Fecal coliforms													
12	13	22	46	400	63	38000	1130	3300	600	7860	430	2630	1460	300
2	283	43	56	166	237	7670	470	3600	600	4760	400	2630	730	460
4	480	93	90	166	433	1400	630	1430	400	1500	430	2560	1000	360
	P. aeruginosa													
12	1	0	8	22	19	1116	113	220	56	1136	143	660	103	50
2	163	2	7	29	53	293	100	183	73	506	126	630	70	30
4	143	5	4	24	137	126	143	283	83	193	1130	4600	83	190
	Enterococci													
12	3	157	300	560	273	77	10	10	0	63	56	0	10	200
2	900	290	400	900	100	40	20	6	40	13	13	30	10	60
4	930	260	260	500	177	13	26	23	130	46	350	30	13	20

APPENDIX A-2. WATER SAMPLING RESULTS: BAYOU ST. JOHN, SUMMER 1977
(organisms per 100 ml.)

Time	Trial Date 7/9	7/16	7/17	7/23	7/24	7/30	7/31	8/6	8/7	8/13	8/14	8/20	8/27	8/28
	E. coli													
12	30	133	113	96	24	600	1030	7830	960	9400	430	3160	3260	630
2	7600	27	56	63	50	10700	500	3930	1400	4200	100	2330	2830	430
4	1960	200	500	130	430	2900	270	3230	1200	960	560	5730	2760	900
	Klebsiella													
12	0	70	3	130	11	430	470	1170	100	6850	130	930	530	200
2	0	7	10	360	13	1530	230	570	160	1330	30	460	560	160
4	70	20	30	300	630	1430	300	1170	300	560	330	1460	460	230
	Fecal coliforms													
12	30	233	106	80	27	930	2750	3230	500	5960	256	1600	1530	560
2	3860	40	63	50	40	2770	830	3000	1030	2500	216	1230	830	360
4	900	300	560	40	570	2130	470	2270	1200	1230	460	1830	1030	930
	P. aeruginosa													
12	1	8	3	14	11	73	130	146	110	1886	173	560	116	43
2	343	4	1	29	20	320	140	116	50	376	110	460	116	43
4	153	5	7	15	73	216	57	100	213	186	1260	500	96	236
	Enterococci													
12	23	430	36	0	450	23	90	360	36	53	10	0	50	76
2	3500	110	96	870	570	43	23	285	360	23	36	30	90	200
4	1100	430	430	830	1330	66	30	293	730	76	490	30	100	130

APPENDIX B. WATER SAMPLING RESULTS BY SITE, SUMMER 1978
(organisms per 100 ml.)

Site	Time	6/10	6/11	6/17	6/18	6/24	6/25	7/1	7/2	7/8	7/9	7/15	7/16
						Trial Date							
Levee Beach: Roped Area		E. coli											
	11	500	255	17	110	125	53	47	5	33	7	13	70
	2	233	173	47	100	53	60	80	160	70	23	3	63
		Klebsiella											
	11	33	3	10	27	3	3	17	1	3	1	0	13
	2	33	0	33	27	10	60	67	17	5	7	0	13
		Enterococci											
	11	23	5	3	27	160	6	80	1	4	34	7	1267
	2	66	0	30	7	317	30	53	57	23	40	3	167
Levee Beach: Bayou Area		E. coli											
	11	500	170	87	153	60	53	40	40	34	3	37	466
	2	300	226	70	130	177	87	33	50	30	47	17	106
		Klebsiella											
	11	66	3	20	23	30	20	40	3	4	0	0	43
	2	160	0	27	17	20	93	17	10	13	0	0	30
		Enterococci											
	11	85	25	166	143	303	20	10	5	14	3	3	767
	2	0	43	87	100	280	30	123	30	19	15	3	116
Fontaine-bleau Beach		E. coli											
	11					11	11	1	23	3	3	3	4
	2					12	23	1	14	1	4	21	8
		Klebsiella											
	11					0	1	0	10	4	1	1	15
	2					1	3	1	1	1	1	3	1
		Enterococci											
	11					17	325	6	10	47	3	4	29
	2					28	120	0	3	30	9	18	13